Santa Lucia Escarpment Model Sound Propagation Measurements with a Sediment Layer

Stewart A.L. Glegg
Dept. of Ocean Engineering
Florida Atlantic University
Boca Raton, FL 33431
phone: (561) 367-2633 fax: (561) 367-3885 e-mail: glegg@oe.fau.edu
Award #: N000149610992

LONG TERM GOALS

To use model scale measurements to enhance the understanding of three dimensional sound propagation in the ocean.

OBJECTIVES

The objective of this work has been to consider the importance of bathymetric refraction caused by realistic sloping bottoms on shallow water sound propagation. By using detailed three dimensional measurements at model scale the sound field can be mapped in far greater detail then would be possible at full scale, and the important three dimensional effects identified more easily.

APPROACH

The Santa Lucia Escarpment model is a 1/10,000-scale replica of the bathymetry of the Santa Lucia Bank and Escarpment off the coast of Santa Barbara, California. The model was constructed in 1990 with a base made of concrete and numerous measurements of the sound propagation in the model basin have been made over the last few years. The sub-bottom of the Santa Lucia Bank and Escarpment is typically basalt and limestone and the geoacoustic properties of concrete proved to be similar. Although previous experiments provided useful results, the concrete base of the tank is a very hard medium relative to the actual sea floor, and was found to be difficult to model numerically. To provide a more realistic tank model base, a polyurethane rubber has now been molded to the concrete to provide a softer lower boundary condition. This report will describe the application of this material and sound propagation results which have been obtained over the modified model.

WORK COMPLETED

The model was modified by coating the concrete base with an epoxy layer. A polyurethane rubber (Polytek 74-30) was selected which simulated the ocean sediments in the modeled area. The thickness of the coating varied from 1 mm to 1 cm and all sound propagation measurements were made at a frequency of 20-kHz (2-Hz full scale). Sound propagation measurements over the modified Santa Lucia model were made during the spring 1999. For this experiment the sound propagation over a shallow water grid 0.86 x 1.30-m was measured at a constant depth. Additionally the propagation as a function of distance and source depth was measured for a near constant bathymetry in the across slope direction and a variable bathymetry in the downslope direction.

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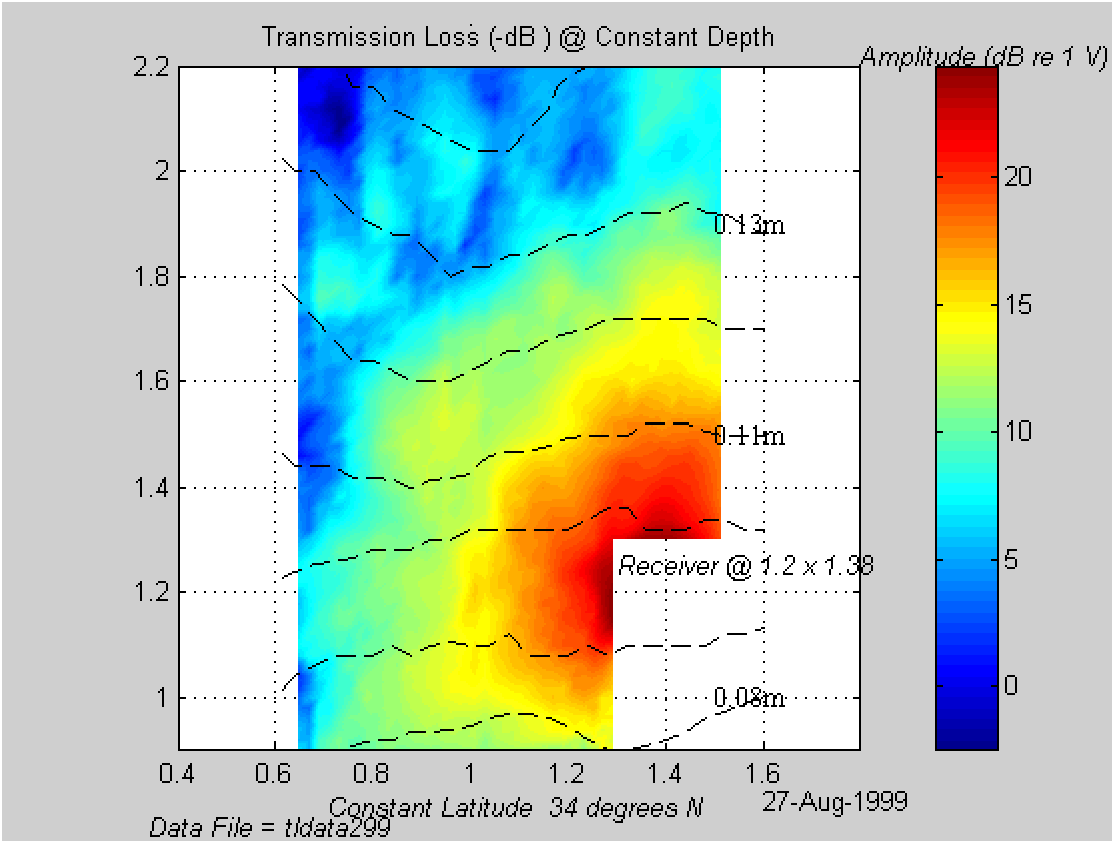
RESULTS

The constant depth measurements were made over the total basin area, while the variable depth measurements were made only at selected points. To check the accuracy of the data, a comparison was made of the variable depth measurements relative to the constant depth measurements at the same transducer depth. Table 1 presents the differences between the Cross-Slope and Constant Depth measurements for the 0.04-m, depth cross-slope data set using two different data interpolation methods. For example, the x9 column, 0.7 m row presents the 0.69 m constant depth value minus the 0.70 m cross-slope value, while the x11 column, 0.7 m row is the 0.71 m constant depth value minus the 0.70 cross-slope value. This table shows that the differences between the measurement sets are small (<0.86 dB for the x9 and < 1.7 dB for the x11 data comparisons). Overall Table 1 shows that the measurements were repeatable

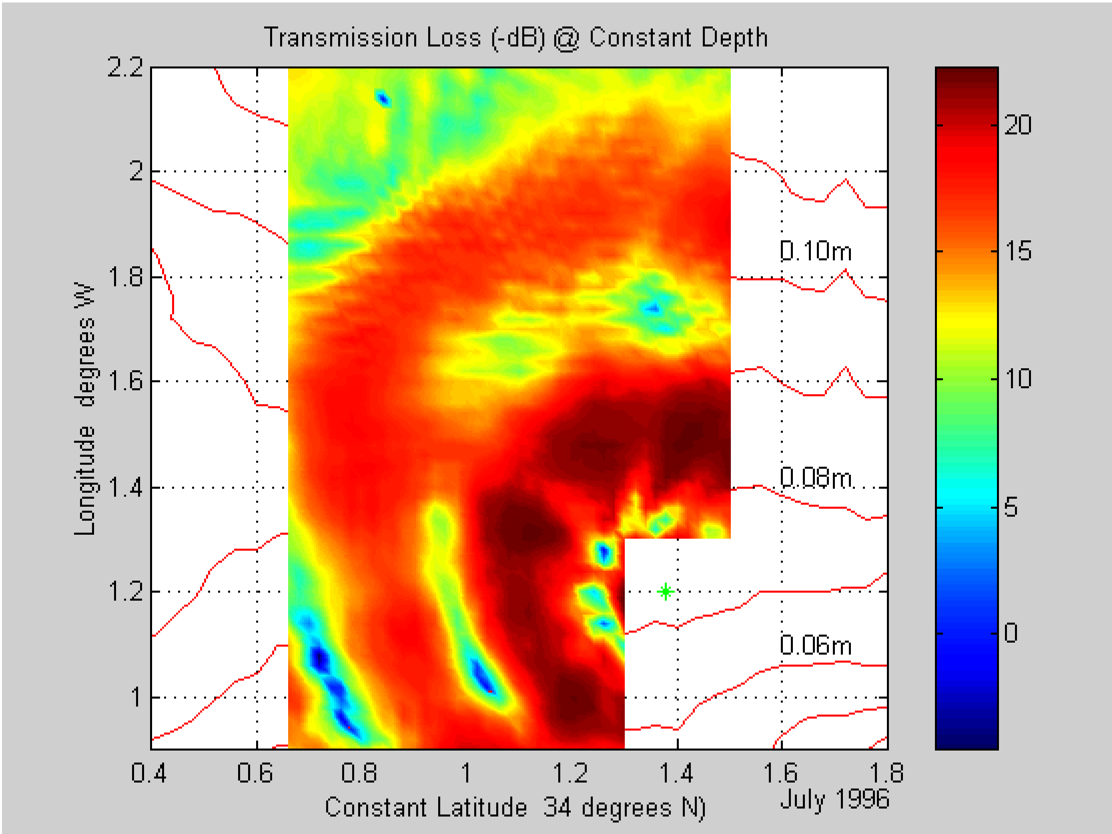
Table 1. Level Differences (Cross-Slope vs. Constant Depth)

Y-Location (m)	**Difference @ x9 (dB)**	**Difference @ x11 (dB)**
0.60	N/A	0.31(0.65 m)
0.70	0.86	0.79
0.80	0.18	0.62
0.90	0.67	1.06
1.00	0.20	1.69
1.10	0.18	0.99
1.20	0.22	1.10
1.30	-0.02	N/A



1: Measurements of Transmission Loss over the Santa Lucia Escarpment model with a soft bottom boundary.

The results of the constant depth measurements are presented in Figure 1 with the bottom bathymetry contours. Figure 1 shows that the amplitude continuously decreased as the source to receiver distance increased, with the lowest levels at the maximum ranges. Comparisons of the amplitude as a function of the source to receiver distance revealed that for a given range, the amplitude varied by less than 3 dB. This variation is caused by the varying bathymetry. These results are expected and differ from previously published data from this tank experiment when the concrete was in direct contact with the water. Figure 2 presents the data measured during November 1996 (experiment setup # 1-3D). The recent measurements duplicated the 1996 measurements, except that the concrete surface of the tank was coated with the rubber polymer. Figure 2 shows that for the bare concrete surface model a high amplitude area was exhibited at approximately 0.4-m source to receiver distance. The addition of the rubber coating to the tank bottom eliminated this ridge of high amplitude data 0.4 m from the receiver by suppressing the formation of apparent modal interference in the tank.



2: Measurements of Transmission Loss over the Santa Lucia Escarpment model with a hard bottom boundary.

IMPACT

In previous measurements of sound propagation over the Santa Lucia Escarpment model it was found that a strong modal interference pattern occurred at low frequencies where only one mode was expected to be supported by the water column. This was unexplained by theoretical considerations based on adiabatic mode theory and unpredicted by numerical models. The hard basement of the tank was difficult to account for in numerical models and there was a question as to whether the numerical modeling was not properly representing either 3D effects or propagation through the concrete. For this reason it was decided to add a softer lower boundary condition to the model so that the environment would be both more realistic of ocean regions with soft sediments and more amenable to numerical calculation of the propagation loss. This report provides the data obtained from the model using a softer lower boundary condition, which will be useful for future studies and calibration of computer codes.

There are however some interesting features of the results which warrant attention. First we note that the strong modal interference dips which were apparent in the original data set over the hard bottom (Figure 2) are not apparent with the sediment layer present (Figure 1). This indicates that the modal interference, observed over the hard bottom was a consequence of the lower boundary condition rather than a 3D effect, which would be less affected by the lower boundary. Secondly, the mode shapes which were measured during this experiment are more typical of those found over a soft bottom with an almost pressure release lower boundary. The previous data included a much larger variation close to the lower boundary indicating a strong effect by interface waves which is now absent. Secondly, close

consideration of the mode shapes indicated that there is more than one mode present in the water column, which is not as expected from theory at this frequency. If this were not the case then the sound field as a function of depth would be consistent with range from the source. In this data set this is not the case since the depth of the maximum level varies with distance from the source. To fully explain this effect detailed numerical calculations are required.